

FORM PTO-1390 (Modified)  
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

R.35976

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09/831025

INTERNATIONAL APPLICATION NO.

PCT/DE 00/02814

INTERNATIONAL FILING DATE

18 AUGUST 2000

PRIORITY DATE CLAIMED

04 SEPTEMBER 1999

TITLE OF INVENTION

**INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES, WHICH HAS AN  
ANNULAR GROOVE IN THE NOZZLE NEEDLE**

APPLICANT(S) FOR DO/EO/US

BOECKING, Friedrich

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Transmittal Sheets in Duplicate w/fees Charged

to Dep. Acct. 07-2100

Copy of German Text Application w/2 Sheets Drawings

Translation of German Text Application w/2 Sheets Drawings

Preliminary Amendment

Copies of PCT/RO/101, 210 and 220

Executed Declaration (Not Enclosed At This Time)

Assignment to Robert Bosch GmbH (Not Enclosed At This Time)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.53)

09/831025

INTERNATIONAL APPLICATION NO.

PCT/DE, 00/02814

ATTORNEY'S DOCKET NUMBER

R.35976

21. The following fees are submitted:

**BASIC NATIONAL FEE ( 37 CFR 1.492 (a) (1) - (5) ) :**

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... \$1,000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... \$860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

\$860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).

☒ 20 ☐ 30

\$130.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	30 - 20 =	10	x \$18.00
Independent claims	- 3 =	0	x \$80.00

\$180.00

\$0.00

Multiple Dependent Claims (check if applicable).

☐

\$0.00

**TOTAL OF ABOVE CALCULATIONS =**

\$1,170.00

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).

☐

\$0.00

**SUBTOTAL =**

\$1,170.00

Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).

☐ 20 ☐ 30

+

\$0.00

**TOTAL NATIONAL FEE =**

\$1,170.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).

☐

\$0.00

**TOTAL FEES ENCLOSED =**

\$1,170.00

Amount to be:  
refunded  
charged

\$  
\$

- ☐ A check in the amount of to cover the above fees is enclosed.
- ☒ Please charge my Deposit Account No. **07-2100** in the amount of **\$1,170.00** to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **07-2100** A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Ronald E. Greigg

NAME

31,517

REGISTRATION NUMBER

04 MAY 2001

DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Friedrich Boecking

Based on PCT/DE 00/02814

For: Injection Nozzle For Internal Combustion Engines, Which Has An Annular

Groove In The Nozzle Needle

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents  
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 1, between the title and first line of the specification, insert the following:

--Cross-Reference to Related Applications

This application is a 35 USC application of PCT/DE 00/02814 filed on August 18, 2000.

Background of the Invention--;

line 3, delete "Prior Art" and insert --Field of the Invention--;

between lines 6 and 7, insert --Description Of The Prior Art--;

between lines 12 and 13, insert --Objects And Advantages Of The Invention--.

Page 2, line 22, before "60°" insert --approximately--.

Page 6, between lines 13 and 14, insert -Brief Description Of The Drawings--;

line 14, delete "advantageous embodiments" and insert --features--;

line 15, delete "can be inferred" and insert --will be apparent--;

same line, after "description," insert --taken with--;

line 16, delete "and the claims." and insert --in which:--;

delete lines 17-19.

Page 7, between lines 6 and 7, insert --Description Of The Preferred Embodiments--.

Page 8, line 17, after "bottom" insert --9--.

Page 14, delete lines 9-12 and insert the following paragraph:

--The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other embodiments and variants thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.--.

Page 15, line 1, delete "Claims" and insert --I Claim--.

## IN THE CLAIMS

Please cancel claims 1-17 and add new claims 18-47.

18. In an injection nozzle (1) for internal combustion engines, which has at least one injection orifice (3), a nozzle needle seat (4), and a nozzle needle (5), the improvement wherein the end of the nozzle needle (5) oriented toward the nozzle needle seat (4) has an annular groove (8).

19. The injection nozzle (1) according to claim 18, wherein the nozzle needle seat (4) is the shape of a truncated cone.

20. The injection nozzle (1) according to claim 19, wherein the cone angle of the nozzle needle seat (4) is approximately 60°.

21. The injection nozzle (1) according to claim 19, wherein the end of the nozzle needle (5) oriented toward the nozzle needle seat (4) is a cone and that the cone angle of the nozzle needle (5) is up to one degree greater than, preferably 15 to 30 angular minutes greater than, the cone angle of the nozzle needle seat (4).

22. The injection nozzle (1) according to claim 19, wherein the annular groove (8) runs parallel to the base surface of the cone.

23. The injection nozzle (1) according to claim 18, wherein a blind hole (2) adjoins the nozzle needle seat (4) and has at least one injection orifice (3).

24. The injection nozzle (1) according to claim 23, wherein when the injection nozzle (1) is closed, the distance of the transition (7) between the blind hole (2) and the nozzle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

25. The injection nozzle (1) according to claim 23, wherein the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm.

26. The injection nozzle (1) according to 23, wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.2 mm, preferably approximately 0.08 mm to 0.14 mm.

27. The injection nozzle (1) according to claim 23, wherein the blind hole (2) is conical.

28. The injection nozzle (1) according to claim 23, wherein the blind hole (2) is cylindrical.

29. The injection nozzle (1) according to claim 23, wherein the blind hole (2) is a mini-blind hole or micro-blind hole.

30. The injection nozzle (1) according to claim 18, wherein the nozzle needle seat (4) has at least one injection orifice (3).

31. The injection nozzle (1) according to claim 30, wherein when the injection nozzle (1) is closed, the distance of the piercing point (16) of the longitudinal axis of the injection orifice(s) (3) through the nozzle needle seat (4) from the bottom (9) of

the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

32. The injection nozzle (1) according to claim 30, wherein the width of the annular groove (8) is greater than, preferably one-and-a-half times greater than, the diameter of the injection orifice(s) (3).

33. The injection nozzle (1) according to claim 30, wherein that the depth of the annular groove (8) is less than the width of the annular groove (8).

34. The injection nozzle (1) according to claim 30, wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.1 mm, preferably approximately 0.04 mm to 0.07 mm.

35. The injection nozzle (1) according to claim 21, wherein the annular groove (8) runs parallel to the base surface of the cone.

36. The injection nozzle (1) according to claim 18, wherein a blind hole (2) adjoins the nozzle needle seat (4) and has at least one injection orifice (3), wherein the nozzle seat (4) is the shape of a truncated cone, and wherein the end of the nozzle needle (5) oriented toward the nozzle needle seat (4) is a cone and that the cone angle of the nozzle needle (5) is up to one degree greater than, preferably 15 to 30 angular minutes greater than, the cone angle of the nozzle needle seat (4).

37. The injection nozzle (1) according to claim 23, wherein when the injection nozzle (1) is closed, the distance of the transition (7) between the blind hole (2) and the nozzle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

38. The injection nozzle (1) according to 18, wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.2 mm, preferably approximately 0.08 mm to 0.14 mm, wherein when the injection nozzle (1) is closed, the distance of the transition (7) between the blind hole (2) and the nozzle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal, and wherein the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm.

39. The injection nozzle (1) according to claim 18, wherein the blind hole (2) is conical wherein when the injection nozzle (1) is closed, the distance of the transition (7) between the blind hole (2) and the nozzle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal, and wherein the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm.



40. The injection nozzle (1) according to claim 18, wherein the blind hole (2) is cylindrical, wherein the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm, and wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.2 mm, preferably approximately 0.08 mm to 0.14 mm.

41. The injection nozzle (1) according to claim 18, wherein the blind hole (2) is a mini-blind hole or micro-blind hole, wherein the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm, and wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.2 mm, preferably approximately 0.08 mm to 0.14 mm.

42. The injection nozzle (1) according to claim 19, wherein the nozzle needle seat (4) has at least one injection orifice (3).

43. The injection nozzle (1) according to claim 21, wherein the nozzle needle seat (4) has at least one injection orifice (3).

44. The injection nozzle (1) according to claim 43, wherein when the injection nozzle (1) is closed, the distance of the piercing point (16) of the longitudinal axis of the injection orifice(s) (3) through the nozzle needle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

45. The injection nozzle (1) according to claim 31, wherein the width of the annular groove (8) is greater than, preferably one-and-a-half times greater than, the diameter of the injection orifice(s) (3).

46. The injection nozzle (1) according to claim 45, wherein that the depth of the annular groove (8) is less than the width of the annular groove (8).

47. The injection nozzle (1) according to claim 46, wherein the depth of the annular groove (8) is approximately 0.02 mm to 0.1 mm, preferably approximately 0.04 mm to 0.07 mm.

IN THE ABSTRACT

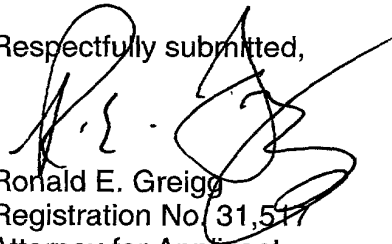
Please substitute the attached Abstract of the Disclosure for the abstract as originally filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

  
Ronald E. Greigg  
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## Abstract Of The Disclosure

An injection nozzle is proposed in which the nozzle needle has an annular groove in the vicinity of the transition between the blind hole and the nozzle needle seat. In seat hole injection nozzles, the annular groove is disposed in the vicinity of the injection orifice(s). The annular groove reduces the tolerance of the flow resistance of the injection nozzle with a partial stroke of the nozzle needle and thus permits a more precise measurement of the fuel quantity injected.

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES  
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum  
Internationales Büro



(43) Internationales Veröffentlichungsdatum  
15. März 2001 (15.03.2001)

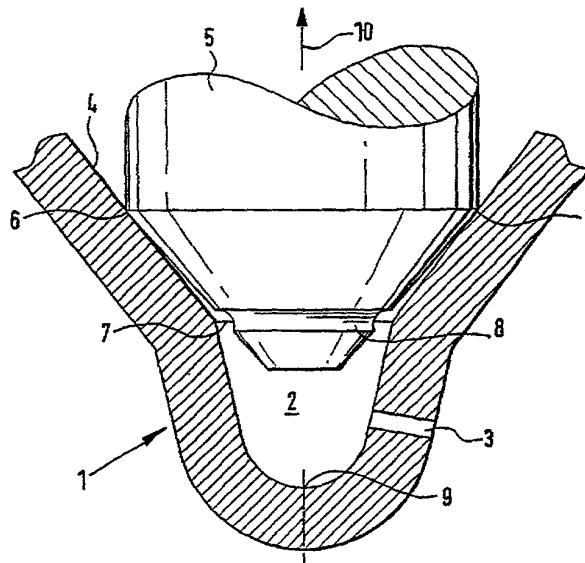
PCT

(10) Internationale Veröffentlichungsnummer  
**WO 01/18387 A1**

- (51) Internationale Patentklassifikation: F02M 61/18 (81) Bestimmungsstaaten (national): JP, KR, US.
- (21) Internationales Aktenzeichen: PCT/DE00/02814 (84) Bestimmungsstaaten (regional): europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
- (22) Internationales Anmeldedatum:  
18. August 2000 (18.08.2000)
- (25) Einreichungssprache: Deutsch Veröffentlicht:  
— Mit internationalem Recherchenbericht.
- (26) Veröffentlichungssprache: Deutsch  
— Vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eintreffen.
- (30) Angaben zur Priorität:  
199 42 370.9 4. September 1999 (04.09.1999) DE
- (71) Anmelder (für alle Bestimmungsstaaten mit Ausnahme von US): ROBERT BOSCH GMBH [DE/DE]; Postfach 30 02 20, 70442 Stuttgart (DE). Zur Erklärung der Zweibuchstaben-Codes, und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.
- (72) Erfinder; und
- (75) Erfinder/Anmelder (nur für US): BOECKING, Friedrich [DE/DE]; Kahlhieb 34, 70499 Stuttgart (DE).

(54) Title: INJECTION NOZZLE FOR AN INTERNAL COMBUSTION ENGINE WITH ANNULAR GROOVE IN SAID NOZZLE NEEDLE

(54) Bezeichnung: EINSPRITZDÜSE FÜR BRENNKRAFTMASCHINEN MIT EINER RINGNUT IN DER DÜSENNADEL



(57) Abstract: The invention relates to an injection nozzle (1) in which a nozzle needle (5) has an annular groove (8) at the bridge (7) between the pocket hole (2) and the seat of nozzle needle (4). In injection nozzles with seat holes said annular groove (8) is located in the vicinity of or at an injection hole(s) (3). The presence of said annular groove (8) lowers the tolerance of the flow resistance of said injection nozzle (1) when the nozzle needle is partially lifted (5) and enables more exact measurement of the amount of fuel injected to be measured with greater accuracy.

[Fortsetzung auf der nächsten Seite]

WO 01/18387 A1

Injection Nozzle for Internal Combustion Engines, Which Has an  
Annular Groove in the Nozzle Needle

Prior Art

The invention is based on an injection nozzle for  
5 internal combustion engines, which has at least one injection  
orifice, a nozzle needle seat, and a nozzle needle.

Injection nozzles of this generic type, primarily in the  
partial stroke range of the nozzle needle, have a large  
variation in the flow resistance and therefore also of the  
fuel quantity injected. As a result of this, the emission and  
consumption behavior of many internal combustion engines  
equipped with these injection nozzles is not optimal.

The object of the invention is to produce an injection  
nozzle in which the variation in the injection quantity in the  
partial stroke range of the nozzle needle is reduced in  
various specimens of an injection nozzle of the same design  
and consequently, the consumption and emission behavior of  
internal combustion engines equipped with the injection  
nozzles according to the invention is improved.

20 This object is attained by means of an injection nozzle  
for internal combustion engines which has at least one  
injection orifice, a nozzle needle seat, and a nozzle needle,

wherein the end of the nozzle needle oriented toward the  
nozzle needle seat has an annular groove.

In the partial stroke range of the nozzle needle, the  
annular groove in the end of the nozzle needle oriented toward  
the nozzle needle seat is decisive for the throttle action of  
the injection nozzle. Since it is possible to manufacture  
annular grooves with high precision reproducibility, there is  
thus very little variation in the throttle action of the  
injection nozzle between specimens of an injection nozzle of  
the same design. For this reason, by measuring the operating  
behavior of an injection nozzle according to the invention,  
the operating behavior of all other injection nozzles of the  
same design can be predicted with significantly greater  
precision and the control of the injection process can be  
correspondingly optimized.

A variant of an injection nozzle according to the  
invention provides that the nozzle needle seat is the shape of  
a truncated cone, which results in a favorable sealing action  
and a favorable centering of the nozzle needle in the nozzle  
needle seat.

In another embodiment of the invention, the cone angle of  
the nozzle needle seat is  $60^\circ$  so that a favorable sealing  
action is produced between the nozzle needle and the nozzle  
needle seat.

In a modification of the invention, the end of the nozzle  
needle oriented toward the nozzle needle seat is a cone and  
the cone angle of the nozzle needle is up to one degree  
greater than, preferably 15 - 30 angular minutes greater than,  
5 the cone angle of the nozzle needle seat so that the sealing  
surface is reduced and is shifted into the vicinity of the  
greatest diameter of the nozzle needle.

In one embodiment of the invention, the annular groove  
runs parallel to the base surface of the cone so that the same  
10 flow conditions prevail over the entire circumference of the  
nozzle needle.

One variant provides that a blind hole adjoins the nozzle  
needle seat and has at least one injection orifice so that the  
advantages of the nozzle needle according to the invention can  
also be used in blind hole injection nozzles.

One embodiment of the invention provides that when the  
injection nozzle is closed, the distance of the transition  
between the blind hole and the nozzle seat from the bottom of  
the injection nozzle and the distance of the annular groove  
20 from the bottom of the injection nozzle are essentially equal  
so that in the partial stroke range of the nozzle needle, the  
throttle action of the injection nozzle is defined by the  
annular groove instead of the transition.

One embodiment of the invention provides that the width of the annular groove is 0.1 mm to 0.3 mm, preferably 0.16 mm to 0.24 mm, so that the annular groove is decisive for the throttle action of the injection nozzle over a sufficiently large partial stroke range. In any case, the annular groove must be large enough that only the leading edge of the annular groove throttles momentarily.

Another embodiment of the invention provides that the depth of the annular groove is 0.02 mm to 0.2 mm, preferably 0.08 mm to 0.14 mm, so that the volume of the annular groove remains low and consequently, so does the quantity of fuel that evaporates when the internal combustion engine is switched off. Nevertheless, the annular groove exerts a sufficient influence on the throttle action of the injection nozzle.

In another embodiment of the invention, the blind hole is conical so that the partial load behavior of conical blind hole injection nozzles is improved.

One modification of the invention provides that the blind hole is embodied as cylindrical so that the partial load behavior of cylindrical blind hole injection nozzles is also improved.

Another embodiment provides that the blind hole is a mini-blind hole or micro-blind hole so that the advantages



according to the invention can be used in these injection  
nozzles as well.

One variant according to the invention provides that the  
nozzle needle seat has at least one injection orifice so that  
the advantages of the nozzle needle according to the invention  
can also be used in seat hole injection nozzles. In seat hole  
injection nozzles, there is also occasionally the problem that  
due to insufficient centering of the nozzle needle in relation  
to the nozzle needle seat, the pressure of the fuel prevailing  
in the injection orifices distributed over the circumference  
is unequal, which can lead to unfavorable conditions in the  
injection. The annular groove can produce a pressure balancing  
between the injection orifices so that the insufficient  
centering of the nozzle needle does not have a negative impact  
on the injection conditions.

Another variant provides that when the injection nozzle  
is closed, the distance of the piercing point of the  
longitudinal axis of the injection orifice(s) through the  
nozzle needle seat from the bottom of the injection nozzle and  
the distance of the annular groove from the bottom of the  
injection nozzle are essentially equal so that in the partial  
stroke range of the nozzle needle, the throttle action of the  
injection nozzle is defined by the annular groove instead of  
the transition from the nozzle needle seat into the injection  
orifice.

In one embodiment of the invention, the width of the annular groove is greater than, preferably one-and-a-half times greater than, the diameter of the injection orifice(s) so that the throttle action of the injection nozzle is influenced by the annular groove over a sufficiently large partial stroke range.

Other embodiments of the invention provide that the depth of the annular groove is less than the width of the annular groove or that the depth of the annular groove is 0.02 mm to 0.1 mm, preferably 0.04 mm to 0.07 mm, so that the volume of the annular groove remains low, but the annular groove nevertheless exerts a sufficient influence on the throttle action of the injection nozzle.

Other advantages and advantageous embodiments of the invention can be inferred from the following description, the drawings, and the claims.

An exemplary embodiment of the subject of the invention is shown in the drawings and will be explained in detail below.

Fig. 1 shows a cross section through a blind hole injection nozzle according to the invention;

Fig. 2 shows a characteristic curve of the hydraulic diameter of a blind hole injection nozzle according to the

invention over the stroke of the nozzle needle;

Fig. 3 shows a cross section through a seat hole injection nozzle according to the invention and

Fig. 4 shows a characteristic curve of the hydraulic diameter of a seat hole injection nozzle according to the invention over the stroke of the nozzle needle.

Fig. 1 shows an injection nozzle 1 with a conical blind hole 2. The blind hole 2 can also be cylindrical or can be a mini- or micro-blind hole 2. In the latter, the volume of the blind hole 2 is reduced in comparison to that of the design shown in Fig. 1. As a result, less fuel evaporates into the combustion chamber when the internal combustion engine is switched off.

The fuel, not shown, travels out of the blind hole 2 via an injection orifice 3 and into the combustion chamber, likewise not shown. The conical blind hole 2 is adjoined by a nozzle needle seat 4 that is the shape of a truncated cone. The nozzle needle seat 4 can have a cone angle of  $60^\circ$ .

A nozzle needle 5 rests against the nozzle needle seat 4. Fig. 1 clearly shows that the cone angle of the nozzle needle 5 is greater than the cone angle of the nozzle needle seat 4. As a result, the contact zone 6 between the nozzle needle 5 and the nozzle needle seat 4 is disposed in the vicinity of

the greatest diameter of the nozzle needle 5 and the surface pressure between the nozzle needle 5 and the nozzle needle seat 4 is increased. The difference between the cone angles of the nozzle needle 5 and the nozzle needle seat 4 is shown in exaggerated fashion in Fig. 1. As a rule, the above-mentioned difference is less than 1 degree and ranges in the vicinity of a few angular minutes.

The transition between the blind hole 2 and the nozzle needle seat 4 according to the prior art is an edge 7 which is produced during the grinding of the nozzle needle seat 4. Depending on the type of machining, the edge 7 can be a sharp burr or a smooth edge. The flow resistance of the edge 7 is significantly influenced by the quality of this edge.

An annular groove 8 that is cut or ground into the nozzle needle 5 reduces the influence of the edge 7 on the flow resistance of the injection nozzle 1. The distance of the annular groove 8 from a bottom of the injection nozzle 1 is approximately the same as the distance of the bottom 9 of the injection nozzle 1 from the edge 7. As a result, independent of the stroke of the nozzle needle 5, the throttle action of the injection nozzle 1 is not influenced by the geometry of the edge 7 or is only influenced to an insignificant degree by it. This effect is based on the fact that because of the hydraulic diameter of the annular gap between the annular groove 8 and the edge 7 - which hydraulic diameter is large in comparison to the annular gap between the nozzle needle seat 4

and the cone of the nozzle needle 5, the flow resistance in the latter annular gap is less than the flow resistance in the former annular gap. Since the two flow resistances are connected in series, essentially the smallest individual resistance is decisive for the flow resistance of the entire injection nozzle.

The sequences of the variation of the flow resistance of injection nozzles 1 in the vicinity of the edge 7 are depicted in the graph shown in Fig. 2. In Fig. 2, the hydraulic diameter 11 of a blind hole injection nozzle 1 is qualitatively plotted over the nozzle needle stroke 10. The hydraulic diameter 11 is a value by means of which arbitrary cross sections that are flowed through can be made comparable with regard to their flow resistance. The flow resistance of a tube with a circular cross section is used as a reference value. A cross section with a large hydraulic diameter has a low flow resistance and vice versa.

In Fig. 2, the nozzle needle stroke 10 has been divided into two ranges. A first range extends from zero to "a"; the second range, which will be referred to below as the partial stroke range, extends from "a" to "b". The full nozzle needle stroke is reached at "c".

When a closed injection nozzle 1, in which the nozzle needle 5 rests against the nozzle needle seat 4, is opened, with a very small nozzle needle stroke 10, a very narrow gap

is produced in the vicinity of the contact zone 6, as a result of which the pressurized fuel can flow into the blind hole 2. This very narrow gap decisively determines the flow resistance of the injection nozzle 1 and therefore also determines the hydraulic diameter 11. Since the flow resistance of this very narrow gap is high, the hydraulic diameter 11 of the injection nozzle 1 is very small with a very small nozzle needle stroke 10.

In the partial stroke range between "a" and "b", the flow resistance of injection nozzles 1 according to the prior art is decisively determined by the edge 7 between the nozzle needle seat 4 and the blind hole 2. Consequently, in the partial stroke range, the edge 7 is also highly significant for the hydraulic diameter of the injection nozzle 1. This means that changes in the geometry of the edge 7 result in changes to the hydraulic diameter 11. In the vicinity of the full nozzle needle stroke "c", the injection orifice 3 of the injection nozzle 1 is decisive for the hydraulic diameter of the injection nozzle 1.

In accordance with the above, variations in the geometry of the edge 7 lead to a change in the characteristic curve 12 of the injection nozzle 1 primarily in the partial stroke range between "a" and "b".

Fig. 2 shows characteristic curves 12 and 13 of an injection nozzle 1 according to the prior art and a

characteristic curve 14 of a blind hole injection nozzle 1 according to the invention. With the injection nozzle 1 according to the prior art, the nozzle needle 5 has no annular groove. Because of the above-described variations in the geometry of the edge 7, the characteristic curves of different specimens of injection nozzles 1 of the same design also vary, particularly in the partial stroke range. This is shown in Fig. 2 by the deviations of the characteristic curves 12 and 13 from each other.

The characteristic curve 14 represents an injection nozzle according to the invention in which the edge 7 does not influence the throttle action, primarily in the partial stroke range, since the fuel can be diverted into the annular groove 8. As a result, the hydraulic diameter 11 of the injection nozzle 1 according to the invention is greater in the partial stroke range than that of injection nozzles 1 according to the prior art. Primarily, however, the characteristic curves 14 of different specimens of injection nozzles 1 with the same design according to the invention vary much less, particularly in the partial stroke range, since the geometry of the annular groove 8 can be manufactured with higher precision reproducibility.

In mass-produced internal combustion engines, the program map of the engine and the associated injection system is determined by measuring one or more selected test specimens.

The program maps that are determined in this manner form the basis underlying all injection systems of the same design.

It will be assumed below that the characteristic curve 12 is a measured characteristic curve and that this characteristic curve 12 is stored in the control unit of the injection system. It is also assumed that an injection nozzle 1 selected from the mass production has the characteristic curve 13. If the injection nozzle 1 with the characteristic curve 13 cooperates with a control unit in which the characteristic curve 12 is stored, then the actual injection quantity in the partial stroke range of the injection nozzle 1 with the characteristic curve 13 does not coincide with the optimal injection quantity according to the characteristic curve 12 measured in the test specimens so that the power and/or emission behavior of the internal combustion engine is impaired.

With the injection nozzles 1 according to the invention, the characteristic curves 14 vary to only an extremely slight degree so that in all internal combustion engines equipped with injection nozzles 1 according to the invention, the correspondence between the characteristic curve 14 stored in the control unit and the characteristic curves 14 of the installed injection nozzles 1 is significantly improved. In comparison to the variation in injection nozzles 1 according to the prior art, the correspondence can, for example, be improved by a factor of 2 to 3. As a result of this, the fuel



quantity actually injected corresponds precisely with the injection quantity preset by the control unit and the consumption and emission behavior of the internal combustion engine is optimal.

Fig. 3 shows an injection nozzle 1 according to the invention, with injection orifices 3 embodied as seat holes. The reference numerals correspond to the related numerals in Fig. 1. The essential difference lies in that in the partial stroke range, instead of the edge 7, the transition 15 between the nozzle needle seat 4 and the injection orifices 3 is decisive for the flow resistance of the injection nozzle 1. In seat hole injection nozzles, the annular groove 8 according to the invention is disposed at the level of the injection orifices 3 so that the influence of the transition 15 between the nozzle needle seat 4 and the injection orifices 3 on the flow resistance of the injection nozzle is sharply reduced. The distance of the annular groove 8 from the bottom 9 of the injection nozzle 1 is approximately equal to the distance between the bottom 9 of the injection nozzle 1 and a piercing point 16 of the longitudinal axis of the injection orifice 3 through the nozzle needle seat 4. As a result, independent of the stroke of the nozzle needle 5, the throttle action of the injection nozzle 1 is not influenced by the geometry of the transition 15 or is only influenced to an insignificant degree by it.

Fig. 4 shows the characteristic curve 12 of an injection nozzle 1 according to the prior art and the characteristic curve 14 of a seat hole injection nozzle 1 according to the invention.

5           That which is mentioned above in relation to blind hole injection nozzles also applies correspondingly to the seat hole injection nozzles according to the invention, with the differences mentioned.

10           All features contained in the description, the following claims, and the drawings can be essential to the invention both individually and in arbitrary combinations with one another.

## Claims

1. An injection nozzle (1) for internal combustion engines, which has at least one injection orifice (3), a nozzle needle seat (4), and a nozzle needle (5), characterized in that the end of the nozzle needle (5) oriented toward the nozzle needle seat (4) has an annular groove (8).

2. The injection nozzle (1) according to claim 1, characterized in that the nozzle needle seat (4) is the shape of a truncated cone.

3. The injection nozzle (1) according to claim 2, characterized in that the cone angle of the nozzle needle seat (4) is approximately 60°.

4. The injection nozzle (1) according to one of claims 2 or 3, characterized in that the end of the nozzle needle (5) oriented toward the nozzle needle seat (4) is a cone and that the cone angle of the nozzle needle (5) is up to one degree greater than, preferably 15 to 30 angular minutes greater than, the cone angle of the nozzle needle seat (4).

5. The injection nozzle (1) according to one of claims 2 to 4, characterized in that the annular groove (8) runs parallel to the base surface of the cone.

6. The injection nozzle (1) according to one of the preceding claims, characterized in that a blind hole (2) adjoins the nozzle needle seat (4) and has at least one injection orifice (3).

7. The injection nozzle (1) according to claim 6, characterized in that when the injection nozzle (1) is closed, the distance of the transition (7) between the blind hole (2) and the nozzle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

8. The injection nozzle (1) according to claim 6 or 7, characterized in that the width of the annular groove (8) is approximately 0.1 mm to 0.3 mm, preferably approximately 0.16 mm to 0.24 mm.

9. The injection nozzle (1) according to one of claims 6 to 8, characterized in that the depth of the annular groove (8) is approximately 0.02 mm to 0.2 mm, preferably approximately 0.08 mm to 0.14 mm.

10. The injection nozzle (1) according to one of claims 6 to 9, characterized in that the blind hole (2) is conical.

11. The injection nozzle (1) according to one of claims 6 to 9, characterized in that the blind hole (2) is cylindrical.

12. The injection nozzle (1) according to one of claims 6 to 11, characterized in that the blind hole (2) is a mini-blind hole or micro-blind hole.

13. The injection nozzle (1) according to one of claims 1 to 5, characterized in that the nozzle needle seat (4) has at least one injection orifice (3).

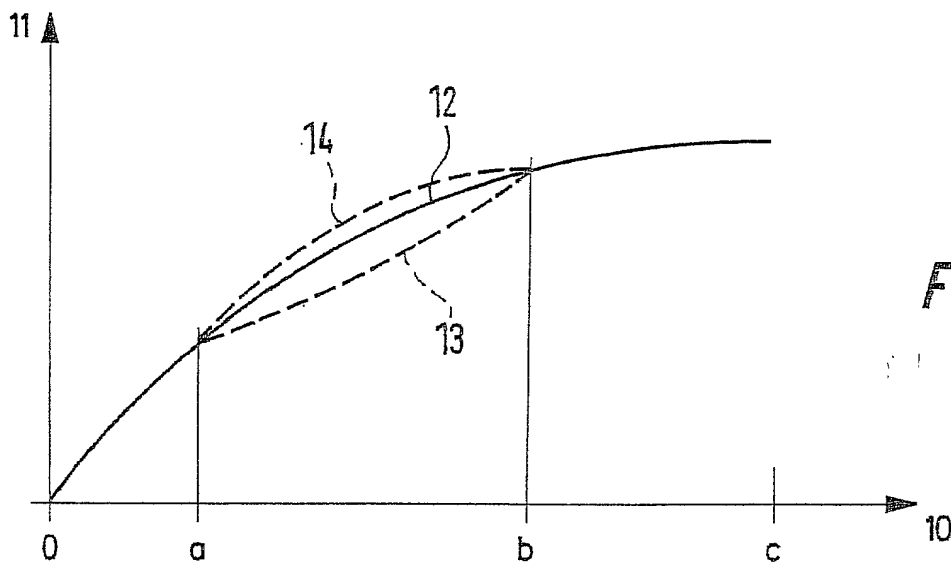
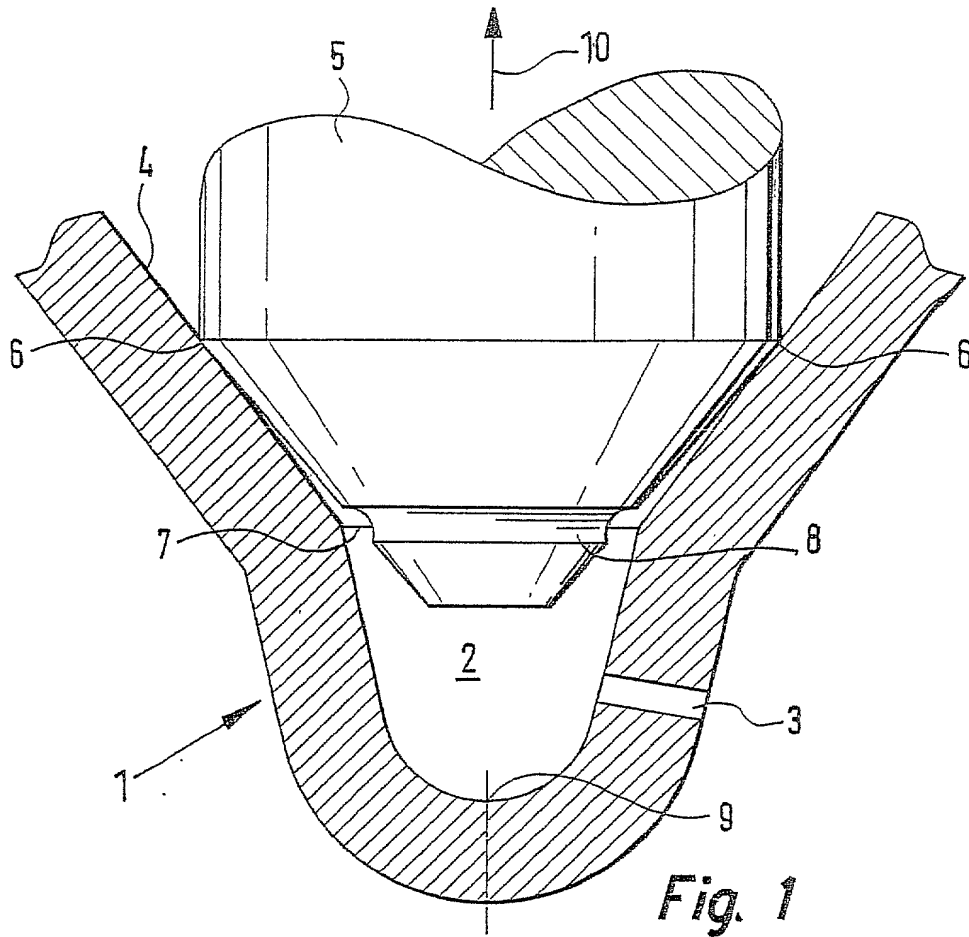
14. The injection nozzle (1) according to claim 13, characterized in that when the injection nozzle (1) is closed, the distance of the piercing point (16) of the longitudinal axis of the injection orifice(s) (3) through the nozzle needle seat (4) from the bottom (9) of the injection nozzle (1) and the distance of the annular groove (8) from the bottom (9) of the injection nozzle (1) are essentially equal.

15. The injection nozzle (1) according to claim 13 or 14, characterized in that the width of the annular groove (8) is greater than, preferably one-and-a-half times greater than, the diameter of the injection orifice(s) (3).

16. The injection nozzle (1) according to one of claims 13 to 15, characterized in that the depth of the annular groove (8) is less than the width of the annular groove (8).

17. The injection nozzle (1) according to one of claims 13 to 16, characterized in that the depth of the annular groove (8) is approximately 0.02 mm to 0.1 mm, preferably approximately 0.04 mm to 0.07 mm.

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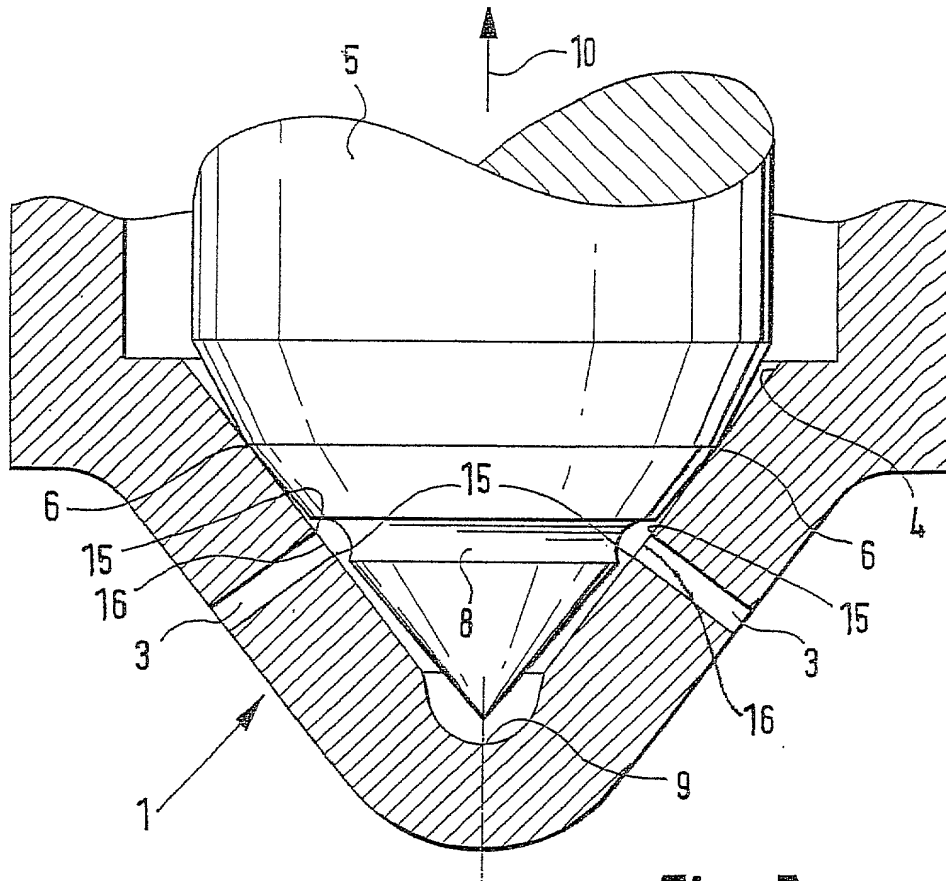


Fig. 3

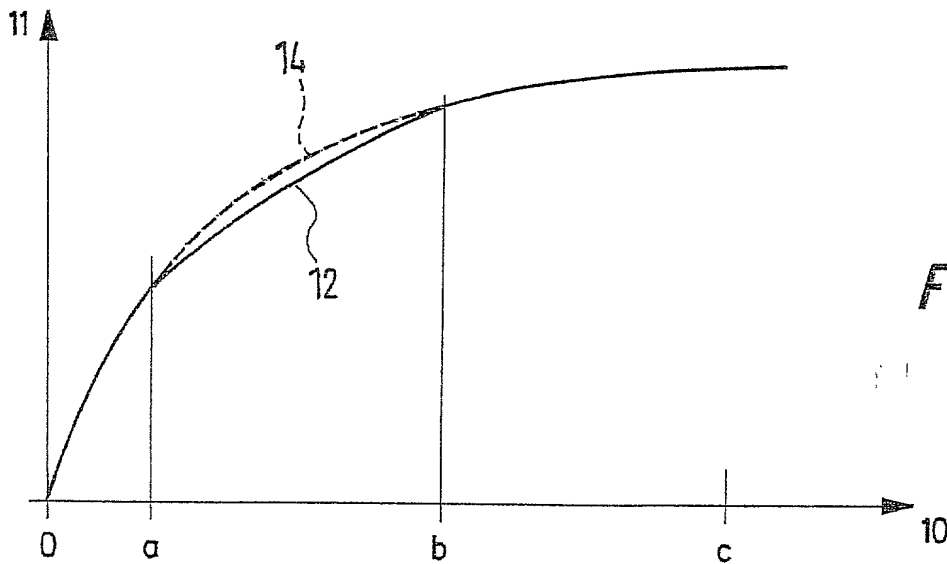


Fig. 4



Docket No.

R.35976

# Declaration and Power of Attorney For Patent Application

## English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES, WHICH HAS AN ANNULAR GROOVE IN THE NOZZLE NEEDLE**

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 18 AUGUST 2000 as United States Application No. or PCT International Application Number PCT/DE 00/02814 and was amended on \_\_\_\_\_

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

1 99 42 370.9

(Number)

GERMANY

(Country)

04 September 1999

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

\_\_\_\_\_  
(Application Serial No.)

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(Filing Date)

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(patented, pending, abandoned)

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(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

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(Status)  
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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